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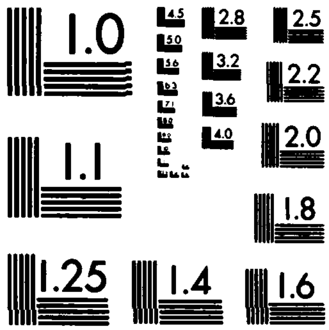

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Final Technical Report
August 1983

DATA HANDLING AND RECORDING SYSTEM

Harris Corporation

Paul Merry and Dennis Dalman

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, NY 13441

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The Data Handling/Recording System (DH/RS) is a near-real time, ground softcopy imagery exploitation system providing automatic target detection/classification, digital storage/processing and image interpretation/exploitation capabilities. The purpose of the DH/RS is to provide an exploitation system to process sensor imagery and generate a report in five minutes or less.

The DH/RS has the capability of ingesting screening, storing and

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exploiting sensor imagery from Pave Tack AN/AAQ-9 FLIR (Forward Looking Infrared) and AN/AAD-5 DLIR (Downward Looking Infrared) sensors.

The DH/RS was designed in a modular-mode to accommodate future upgrading and provides a significant step toward the development of tactical image (reconnaissance) exploitation systems.

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ABSTRACT

The Data Handling and Recording System (DHRS) is an image reconnaissance, exploitation system providing automatic target detection/classification, digital storage/processing, and image interpretation/exploitation. The primary purpose of DHRS is to decrease the time it takes to process sensor imagery and generate a report.

The DHRS is capable of ingesting, screening, storing, and expoiting imagery from Pave Tack FLIR (875-line and 525-line) and AN/AAD-5 DLIR sensors. The inputs to DHRS are imagery video tapes. The outputs are hardcopy photographs and target location reports in a standardized military format.

The DHRS is an advanced development model built with all equipment colocated in a tranportable van. The ultimate mission is mobile, ground-based, tactical image reconnaissance and exploitation.

INTRODUCTION

This report is the final report for the Data Handling and Recording System (DHRS). This report describes the technical work accomplished during the development of DHRS, the methodology used to design and build DHRS, and the resulting system components. References are made to each of the system components to applicable, detailed documentation. The conclusions and recommendations itemize the salient technical features and concerns, while suggesting future efforts for enhancement and upgrading.

GENERAL

The purpose of the Data Handling Recording System is to rapidly exploit imagery data from forward and downward looking airborne electro/optical (E/O) sensors.

DHRS is an advanced development model which utilizes state-of-the-art automatic screening (target detection and classification), and digital storage and processsing techniques to facilitate near-real-time exploitation. The primary goal of DHRS is to decrease the time delay associated with the reconnaissance cycle. In particular, DHRS provides the image interpreter (I/I) capabilities to access targeted imagery within 5 minutes of initial ingest of imagery into DHRS.

The equipment included within the DHRS provides the capability for analog/digital conversion of input imagery; extraction and utilization of aircraft/sensor parameters from the source data tapes; storage of the data for subsequent processing and archiving; image processsing (including rectification and enhancements); interface to devices for automatic target detection/classification; image display for operator analysis and validation; and automatic report generation. Provisions are included to automatically queue to the display those frames of the input imagery which contain classified (cued) targets.

The DHRS provides the capability to access and exploit mission imagery in 5 to 10 minutes near-real-time (semiautomatic) and in 5 minutes or less real-time (automatic), based on an assumption that the mission data-taking time duration does not exceed 2.0 minutes. In conjunction with the requirements, the following definitions apply:

> Semiautomatic Exploitation - The sequence whereby the operator (manually) requests a frame of imagery; the frame is retrieved from the S/RM tape recover, routed through the RTPM and displayed with cued targets from at the I/I display console.
>
> Automatic Exploitation - the sequence whereby sensor data is ingested, stored by the S/RM tape recorder, processed by the RTPM, and cued target frames are retrieved from the S/RM and displayed in prioritized order at the I/I display console.

The flexibility is also included which allows an operator to selectively display any additional portion of the input image and route this information through the automatic target detection/classification equipment.

The DHRS provides significant improvements in the speed and accuracy of performing the analyses and interpretation of airborne reconnaissance imagery. The system automates major operations currently performed by an Image Interpreter (I/I) including target detection, target classification, and generation of target identification/location reports.

Human operators associated with the system validate all identified targets prior to report generation and have overriding authority to review portions of or all of the input imagery, independent of the automated system functions.

Reconnaissance data is provided to the DHRS in the form of video imagery tapes and the outputs are photographs or hard copy printouts prepared in standard military format which provide target identification and location information.

All equipment associated with the system is colocated within a single air-conditioned movable van, whose primary source of ac power is provided through an external power cable.

The DHRS configuration provides the capability to process analog video tape recordings of Pave Tack (575 and 875 line FLIR) and AN/AAD-5 down looking infrared (DLIR) imagery data. Engineering changes will allow digitized FLIR video from HBR-3000 tape recordings to be processed. However, the DHRS is configured in a manner which will facilitate future growth to accommodate the processing of data from more advanced sensors and data provided in an all digital format.

A detailed DHRS system description may be found in the DHRS Functional Description Document, Harris 800848, and the Data Requirements Document, Harris 800849.

DHRS Subsystem Definition

As shown in Figure 1.0, the DHRS shall be partitioned into four major subsystems inclusive of the following:

- Sensor Input Module (SIM)
- Storage and Retrieval Module (S/RM)
- Near-Real-Time Exploitation Module (NRTEM)
- Real-Time Processing Module (RTPM)

The Sensor Input Module (SIM) subsystem accepts the input data from the video tape recorders, performs data A/D conversion, and distributes this data simultaneously to both the S/RM and RTPM. The SIM also decommutates navigation sensor parameter data from the DLIR imagery tapes for the purposes of DLIR rectification and the determination of target location.

The Storage and Retrieve Module (S/RM) provides an archival long-term storage capability for imagery data ingested into the system and also permits an Image Interpreter (I/I) to recall selected frames for display.

The Real Time Processing Module (RTPM) provides the capability for automatic target detection/classification.

The Near Real-Time Exploitation Module (NRTEM) is partitioned into two functional submodules, the Image Processor Display Control (IP/DC) and System Control Module (SCM).

The IP/DC contains an I/I console for the imagery interpretation operation of the DHRS. This console is primarily used for the validation of the target detection/classification results; however, the capability shall be included to display any selected frame previously recorded by the S/RM. In the normal mode of operation, the operator is only presented with image frames containing target information; those which were cued target frames are queued to the I/I display console in a predefined order.

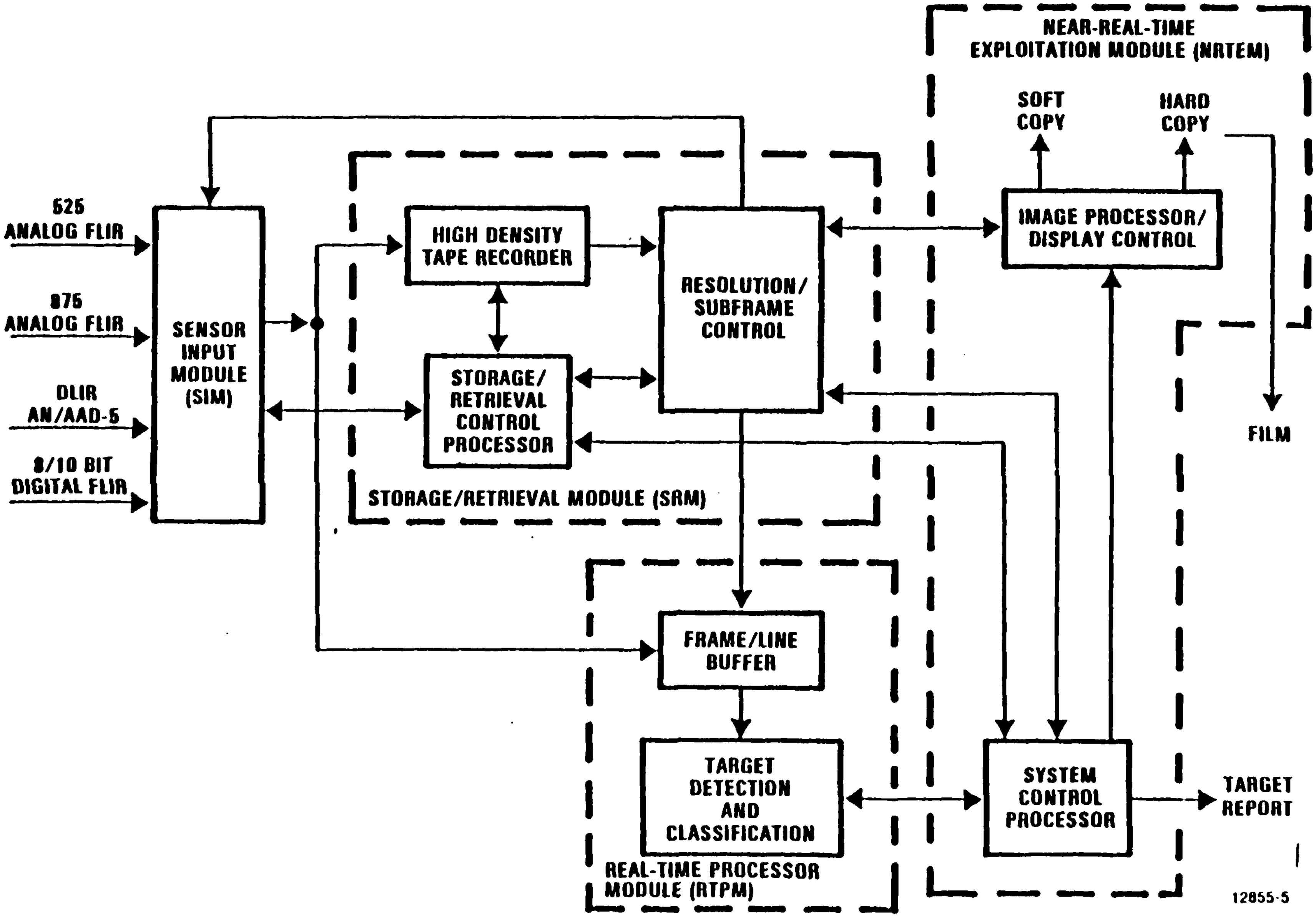

Figure 1.0 DHRS Configuration

The System Control Module (SCM) associated with the NRTEM manages, directly or indirectly, all operations performed by the DHRS. The SCM includes a software programmable, commercial, off-the-shelf general purpose processor and peripherals (SCP). Functionally, the SCP is utilized to generate system initialization data, based on operator inputs, accept and process target cues from the RTPM, and generate hard copy target detection/location reports in standard military format, using DIAM-57-5 as a guide.

In addition, the SCM contains a Voice Recognition Unit (VRU) which may be trained to each I/I's voice, and which provides another input source of DHRS commands.

Methods:

The DHRS design and build methodology stressed modularity and future growth. The intent was to provide a system which could accommodate future enhancements easily. The DHRS was designed and built using a philosophy motivated by the van mounted requirement, and the use of as much off-the-shelf hardware and software as possible. Chassises were designed and built to best commercial practice (i.e., non-militarized). The use of commercial off-the-shelf hardware and software provided the basis for subsystem component selection, where possible. For DHRS, this resulted in the selection of Westinghouse as a subcontractor for the automatic target recognizer (ATR), using their Auto-Q processor. Westinghouse adapted their Auto-Q to the DHRS application, and developed custom hardware and software. The Auto-Q is a major component within the Real-Time Processing Module. Comtal was chosen as a subcontractor for the image processing display control element of the near-real-time exploitation module. Comtal adapted the Vision one-20 to satisfy all of the DHRS requirements, while providing additional design and development support for the custom interfaces. Other major component selections included the DEC PDP 11/44 processor for the system control processor, and the Honeywell HD-96 tape drive for the storage/retrieval module imagery archival storage device.

The use of commercially available, non-militarized components satisfied the EMI/EMC requirements. The overall integrated electromagnetic compatibility (EMC) program which was established, ensured that the subsystem/equipment was designed to operate in its designated location without adversely affecting or being affected by other equipment. Requirements of MIL-STD-461A, Notice 3, Class A3, apply to future production hardware and were implemented as design goals only for the hardware of this ADM. All equipments conform to the electromagnetic compatibility specification MIL-E-6051D. Future production models will be designed to meet the requirements of MIL-STD-461A, Notice 3, Class A3 and will be tested to MIL-STD-462 (Notice 2) to verify that MIL-STD 461A limits have been met. All equipments were demonstrated to MIL-E-6051D.

The imagery data base used as input DHRS was provided by the customer. The data base included DLIR imagery from the Quick Strike Reconnaissance Mission, 525 FLIR imagery, and 875 FLIR imagery. The DLIR imagery was supplied on video tape for use on the GFE RCA Advisor-62 VTR. The 525 FLIR was supplied on video cassette, and the 875 FLIR was provided on video cassette and on video tape.

At the time Westinghouse developed the signatures for each of the target classes applicable to DHRS, only a limited subset of imagery was available. In particular, the 525 FLIR imagery consisting of tanks, trucks, and APC's was given to Westinghouse to facilitate training and signature generation. No DLIR or 875 FLIR imagery was available during the time of signature.

Initially the imagery data base was to be unclassified. However, much of the data base proved to be classified, necessitating additional security considerations, for the van and equipment.

Results:

The completed DHRS was tested per the DHRS ATP procedure, Harris 148180. The DHRS ATP is a system level test consisting of the following steps:

1. DHRS initialization and voice recognition training
2. 525 FLIR processing
3. 875 FLIR processing
4. DLIR data processing

The results of the DHRS system ATP are documented in DHRS ATP results, Harris 160351.

The ATP provided quantitative results as to DHRS performance. The 5 minute time line performance requirement measured from the start of ingest and screening of imagery to the display of the first targeted frame, was passed successfully.

During ATP the voice input unit was used to provide an alternative input source for the operator. The voice recognition unit was trained on a set of key vocabulary words which was recalled from the SCP disk units.

During the ATP the performance of the Auto-Q was not tested. Due to the lack of ground truth data, we were unable to provide target recognition performance statistics.

In order to fulfill the EMC/EMI requirements, a survey was performed as part of the ATP, which produced a DHRS EMC profile.

All imagery exploitation functions were demonstrated during the ATP.

The following paragraphs specify the technical work accomplished during this contract through a summary of the technical characteristics of each subsystem. Refer to the DHRS system block diagram (Figure 1.0) to identify each of the subsystems discussed below.

The SIM as built processes video tape data (imagery) produced by various IR sensors and formats onto a single common digital imagery bus. The single imagery bus transfers data to the Storage/Retrieval Module and Real-Time Processing Module at the ingest rate of 144 Mbits/second.

The functions performed by the SIM include the following:

- Receive and separate imagery, documentation (DLIR only), and synchronization data.
- Convert analog imagery data to digital imagery data.
- Format and buffer all digital data to be forwarded to the S/RM and RTPM modules in DHRS for the purpose of data storage and processing.
- DLIR rectification.

All hardware associated with the SIM, as shown in Figure 2.0, was designed and built specifically for DHRS by Harris.

As the front-end data receiving and processing components of DHRS, the SIM receives and formats imagery and documentation (DLIR only) data from the following infrared sensors:

- 525-Line FLIR
- 875-Line FLIR
- AN/AAD-5 DLIR
- Other digital FLIR formats from the HBR-3000 TR

The output of the SIM consists of digitized IR imagery data quantized to a precision of 6 to 12 bits/pixel and digital documentation data (vehicle and sensor parameters). The maximum output data rate is 144 Mb/s. This imagery data and documentation data is simultaneously transmitted to the Storage and Retrieval Module (S/RM) and the Real-Time Processing Module (RTPM).

Specific details concerning the SIM can be found in the System/Subsystem Specification, Harris 800843.

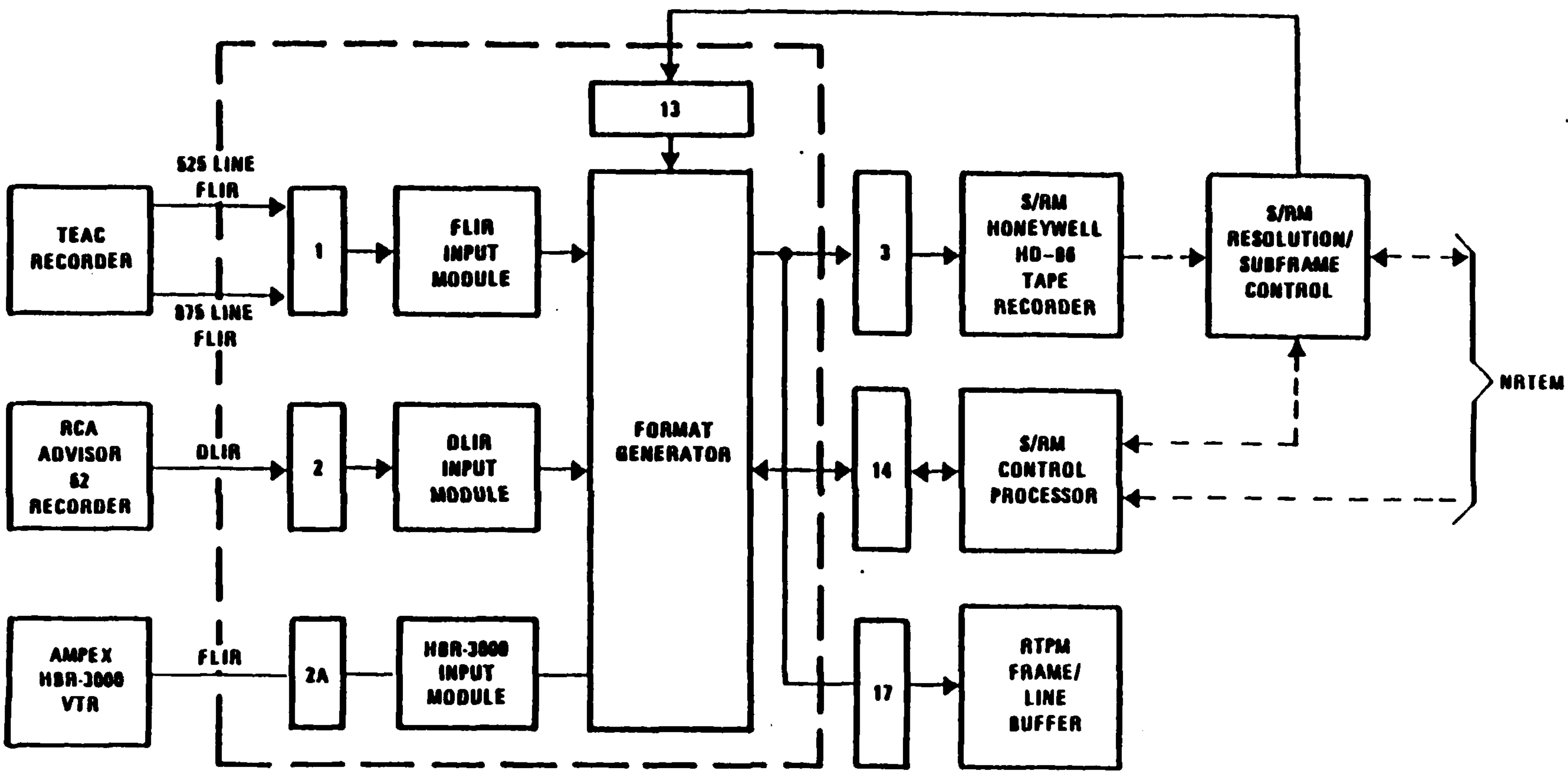

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Figure 2.0. Sensor Input Module Block Diagram

The RTPM processes digitized imagery to provide the DHRS automatic target detection/classification function. Imagery is input to the Frame/Line Buffer from either the video tapes via the SIM, the I/I's imagery console, via the SIM or the S/RM recorder via the S/RM Resolution/Subframe Control. Subsequently, the AUTO-Q or the Rockwell Screener processes the buffered imagery to detect and classify tank, truck, APC, AA gun, missile launcher, SAM site, aircraft and building targets. Target classification, location, type, and confidence factor is output to the System Control Processor which is part of the NRTEM.

Imagery is input at real-time ingest rates (144 Mb/s) and is output at a maximum of 33 target classifications per second.

As a design goal, the RTPM detects 90 percent of the targets correctly and classifies 80 percent of the detected targets correctly. Also, as a design goal, the RTPM misclassifies less than 10 percent of the targets. The average number of false alarms (detections) per frame is not greater than one.

As shown in Figure 3.0, the Frame Line Buffer was developed for DHRS by Harris, with the Auto-Q and Rockwell screeners being subcontracted to Westinghouse and Rockwell, respectively. Specific details of the RTPM may be found in the System Subsystem Specification Harris 800843.

The S/RM as built stores and retrieves digitized imagery and documentation data provided by the SIM. The SIM digitizes and formats data from video tapes and routes the data to the S/RM for DHRS archival storage at real-time ingest rates up to 144 Mb/s. Subsequently, full resolution digitized imagery is retrieved and output to the IP/DC console for display or the F/LB for target detection/classification. Reduced resolution (decimated) imagery is output to the IP/DC console for display at the operator's option.

The S/RM provides the capability to route single frame images from the IP/DC displayed frame memory, via the Resolution/Subframe Control, to the SIM Format Generator. The single frame images are routed in a line-at-a-time manner to the RTPM Screeners for automatic target detection/classification.

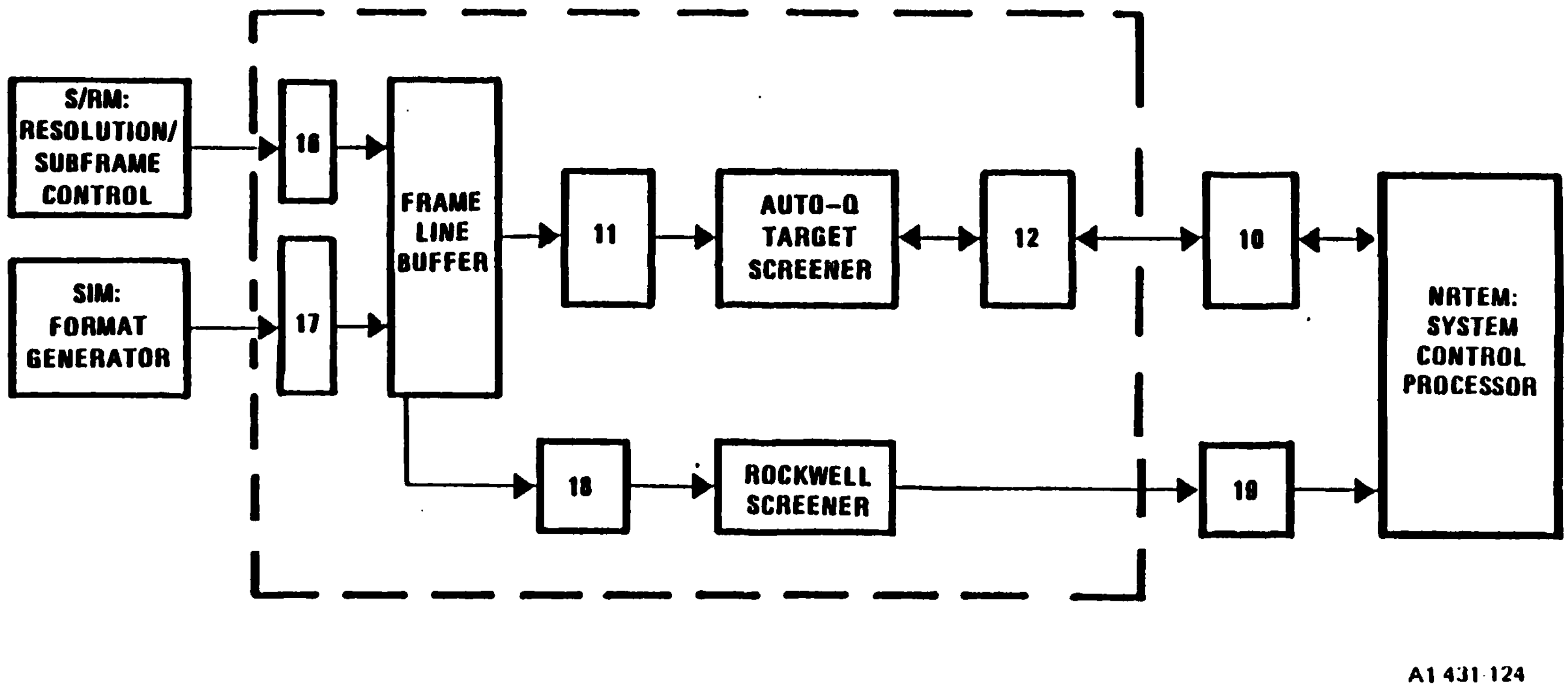

Figure 3.0. Real-Time Processing Module (RTPM) Block Diagram

Additionally, sensor documentation data is retrieved (in either tape record or playback modes) and routed through the Resolution/Subframe Control to the System Control Module.

The S/RM is subdivided into a high density recorder, control processor, and resolution subframe control components. The recorder is a high speed, high density, Honeywell HD-96 commercial magnetic tape recorder. Imagery data is recorded on or played back from 24 tracks at data rates up to 144 Mb/s (or 6 Mb/s/track). The resolution/subframe control provides imagery data decimation, routing, and formatting capability within the S/RM. The control processor principally provides control for the recorder and setup for the imagery frame search and retrieval.

Of the equipment shown in Figure 4.0, the control processor and the resolution subframe control were developed for DHRS by Harris. The HD96 tape recorder was purchased from Honeywell. Specific details concerning the S/RM may be found in the System/Subsystem Specification Harris 800843.

The NRTEM as built provides the man-machine interfaces to control DHRS. An Image Interrupter (I/I) interacts through an imagery console, a system control console, and hard copy printout unit to control DHRS:

a. Imagery ingest storage and retrieval functions.
b. Imagery validation/exploitation functions.
c. Target report generation.
d. Maintenance and training functions.

The NRTEM is subdivided as shown in Figure 5.0, into the Image Process/Display Control (IP/DC) and the System Control Module (SCM). Both elements of the NRTEM are predominately commercial, off-the-shelf equipment. Specific details concerning the NRTEM may be found in the System/Subsystem Specification Harris 800843.

The DHRS system control module software is detailed in the documents:

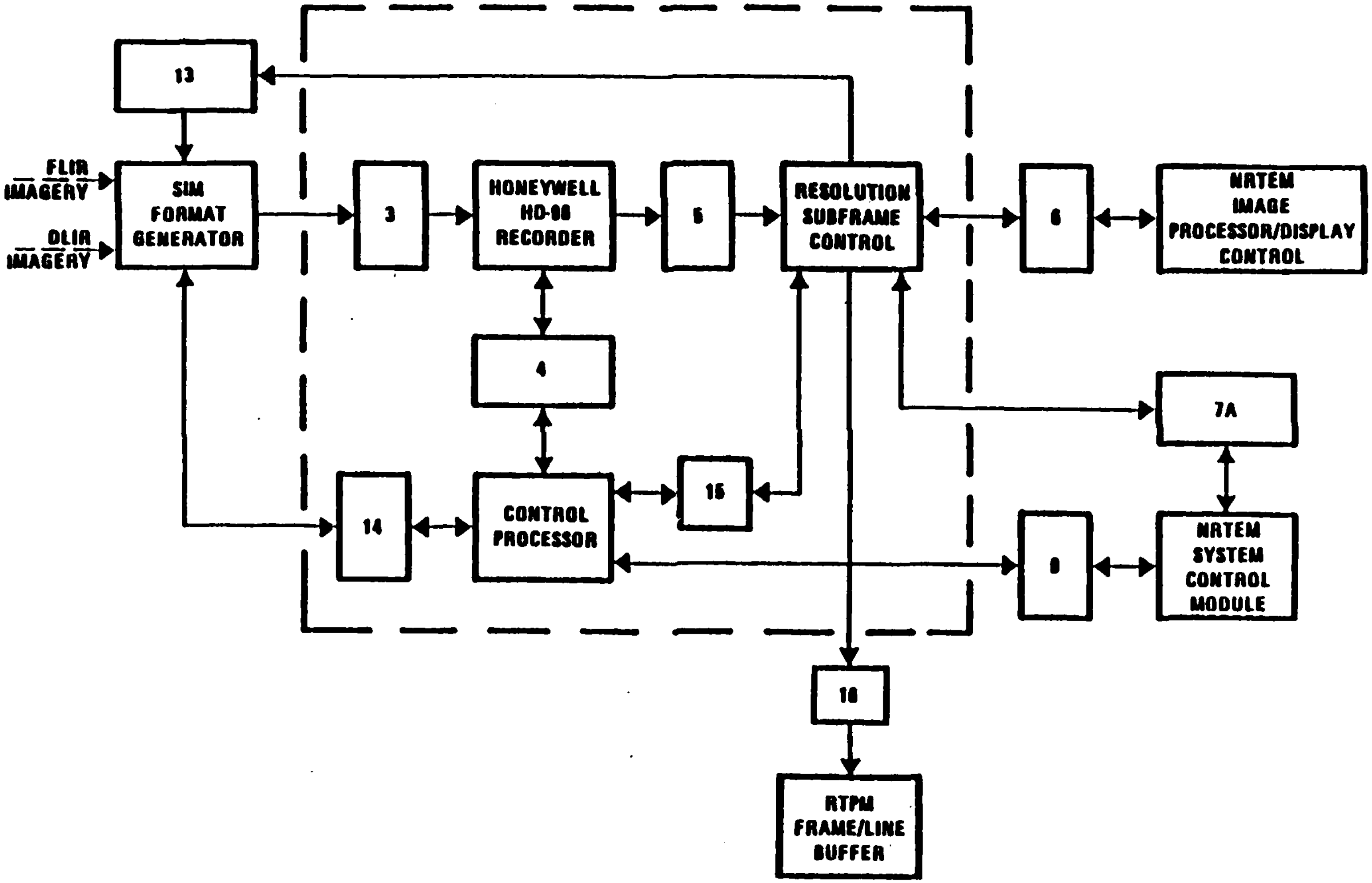

Figure 4.0. Storage/Retrieval Module Interface Block Diagram

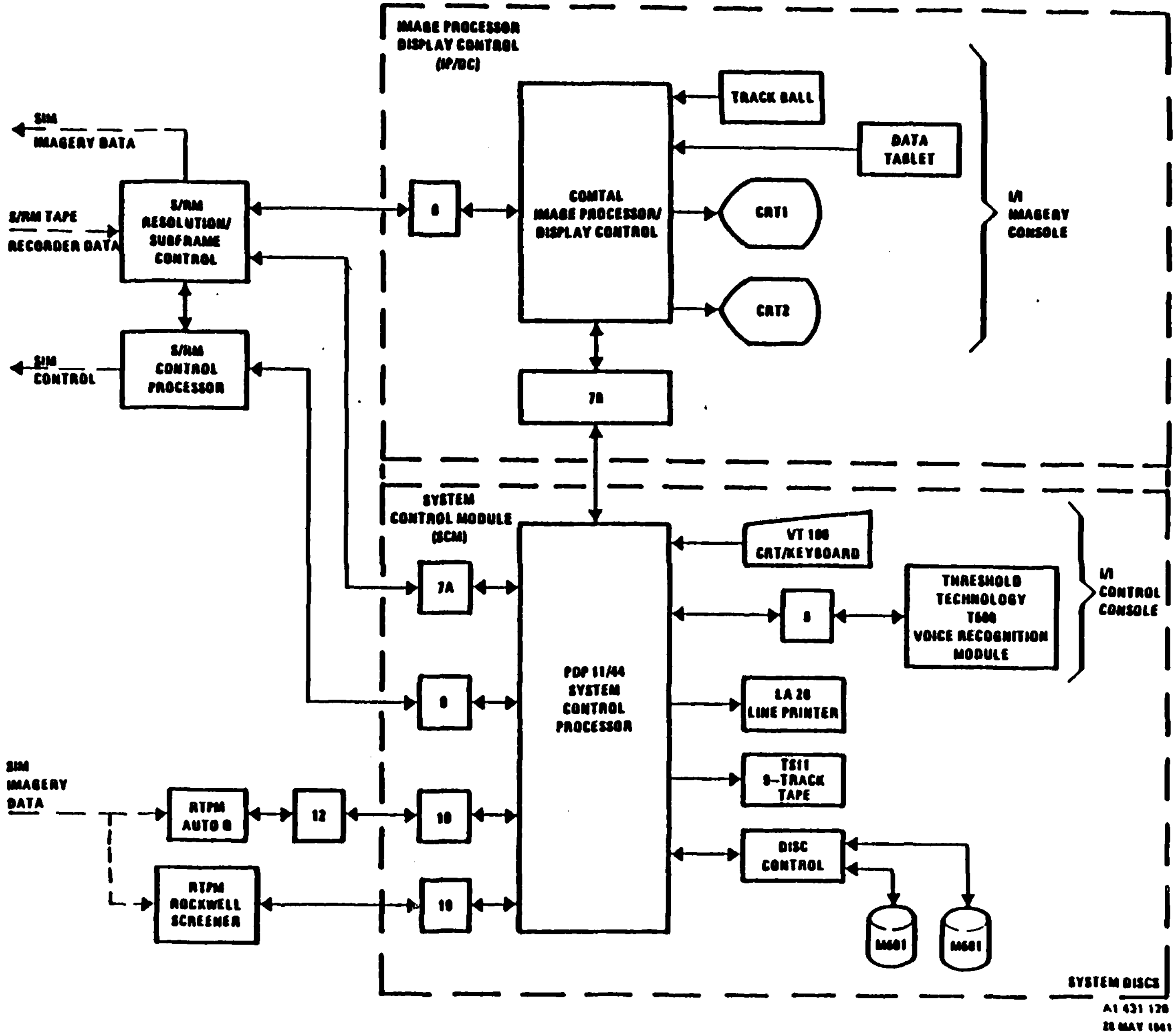

Figure 5.0 Near Real Time Exploitation Module Block Diagram

Data Base Specification, Harris 800844
Computer Operator's Manual, Harris 800845
User's Manual, Harris 8000846
Programmer's Maintenance Manual, Harris 800847

Conclusions:

The Data Handling Recording System provides a significant step toward the development of tactical image reconnaissance exploitation systems. The results of the DHRS ADM indicate that decreased time delay associated with the reconnaissance cycle can be accomplished, while providing image processing capabilities not found in present transportable configurations.

The modular, growth-oriented design and build approach to the DHRS ADM allows for future enhancement to be incorporate and fully integrated with ease.

The DHRS as built, provides all of the capabilities set forth in DHRS statement of work.

Based on the results the DHRS ADM, the following technical conclusions may be identified.

1. The DHRS provides image exploitation for 525 FLIR, 875 FLIR, and an AN/AAD-5 DLIR sensors.
2. DHRS provides automated target detection and classification on a selected class of target categories; tanks, trucks, APC's, SAM sites, missile launchers, anti-aircraft guns, buildings, and aircraft.
3. DHRS provides automated report generation, in a standardized military format.
4. DHRS provides additional image processing capabilities to enable the I/I to verify target classifications.
5. Imagery data rates from the S/RM to the IP/DC were slower then initially anticipated due to Comtal interface limitations.
6. The automated target recognizes need additional real-time vehicle and sensor parameters to improve the detection and classification process.

7. FLIR rectification is a time consuming process taking up to 20 minutes for a 525 FLIR image using the SCP.

Recommendations:

As a result of the DHRS development, the following recommendations are proposed:

As stated in the conclusions, the data rates for imagery into the IP/DC can be improved to allow for faster image transfers from the HD-96 (S/RM).

The automatic target recognizer interface should be modified to allow for direct transfer of real-time sensor documentation data to be transferred to the screener during ingest.

Image processing algorithm execution speeds can be decreased through the use of an array processor.

The overall usefullness of DHRS can be enhanced by providing additional features making DHRS an ATR testing facility.

Should stricter EMC/EMI requirements be necessary in future systems a modification of the van construction should be investigated.

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